



Armed Forces College of Medicine AFCM



Memory

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INTENDED LEARNING OBJECTIVES (ILO)



By the end of this lecture the student will be able to:

- ✓ Classify memory
- ✓ List the types of memory
- ✓ Compare short-term and long-term memory
- ✓ Compare declarative and non-declarative memory
- ✓ List the sites for memory storage in the brain
- ✓ Describe the role of synaptic plasticity in memory



Memory and learning



Learning: It is acquisition of knowledge or skills that alter behaviors or performance as a result of of experience, instruction or both.

Memory: is the retention and storage of that information for later recall.

Classification of memory



A- Temporal Classification:

- I. Immediate memory
- II. Short term memory
- III. Long term memory

B- Physiological classification:

Based on type of information stored how it is stored and recalled

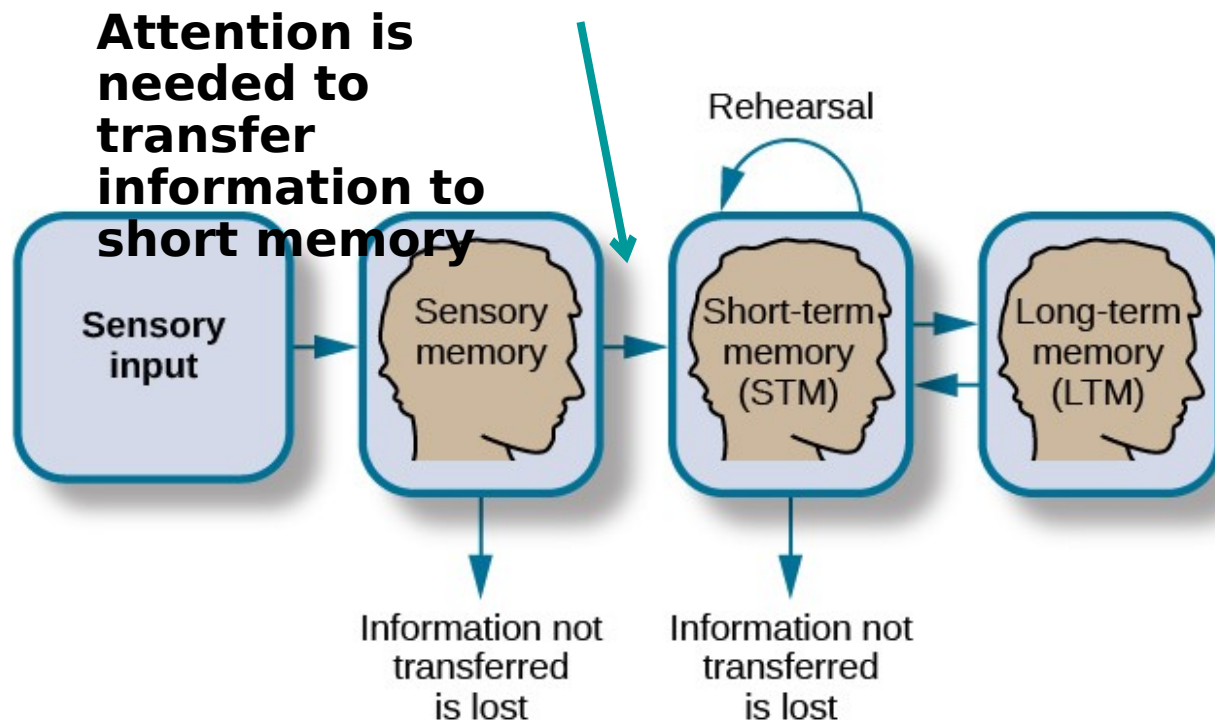
IV. Explicit memory (Conscious) = Declarative (recognition) memory

V. Implicit memory (Unconscious) = Procedural memory = Non declarative (Reflexive) memory

Temporal Classification:



based on the time over which it is effective.



<https://courses.lumenlearning.com/wmopen-psychology/chapter/reading-storage/>

Immediate (sensory) memory

- It is the ability of the brain to hold onto ongoing experience for **a second** or so.
- For example, immediately when close your eyes you can recall a good deal of information from the image you last saw.
- Attention is needed to transfer information to short-term memory.

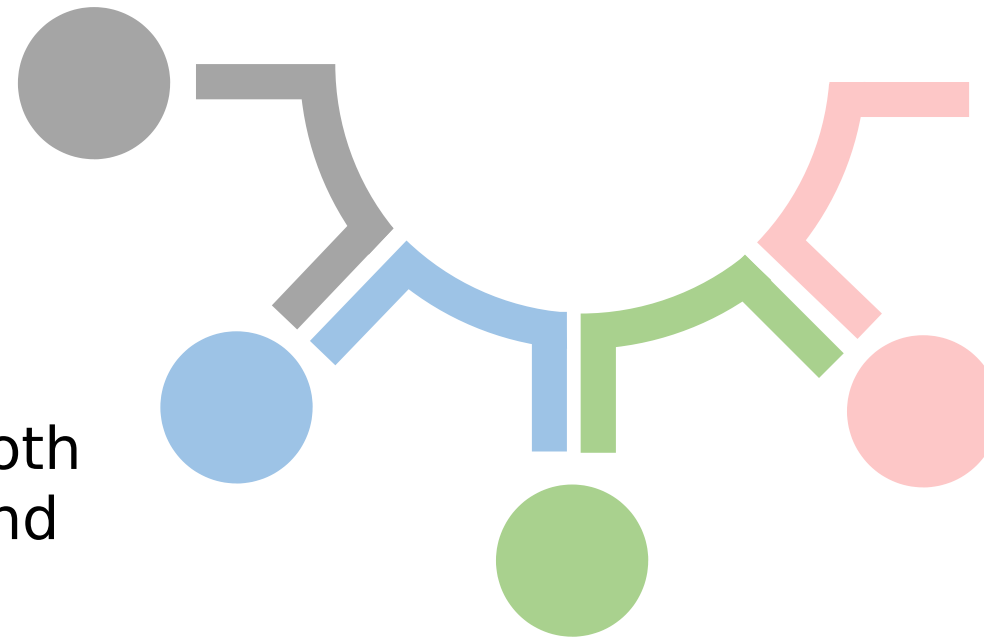
Temporal Classification



Short-term memory:

formed from
immediate
memory and
**lasts for
seconds to
hours**

limited in both
duration and
capacity



**more
vulnerable**

short time for
retrieval

**rapidly and
permanently
forgotten** or
rehearsal, it
**transferred into
long-term memory**,
by a process called
consolidation

Temporal Classification



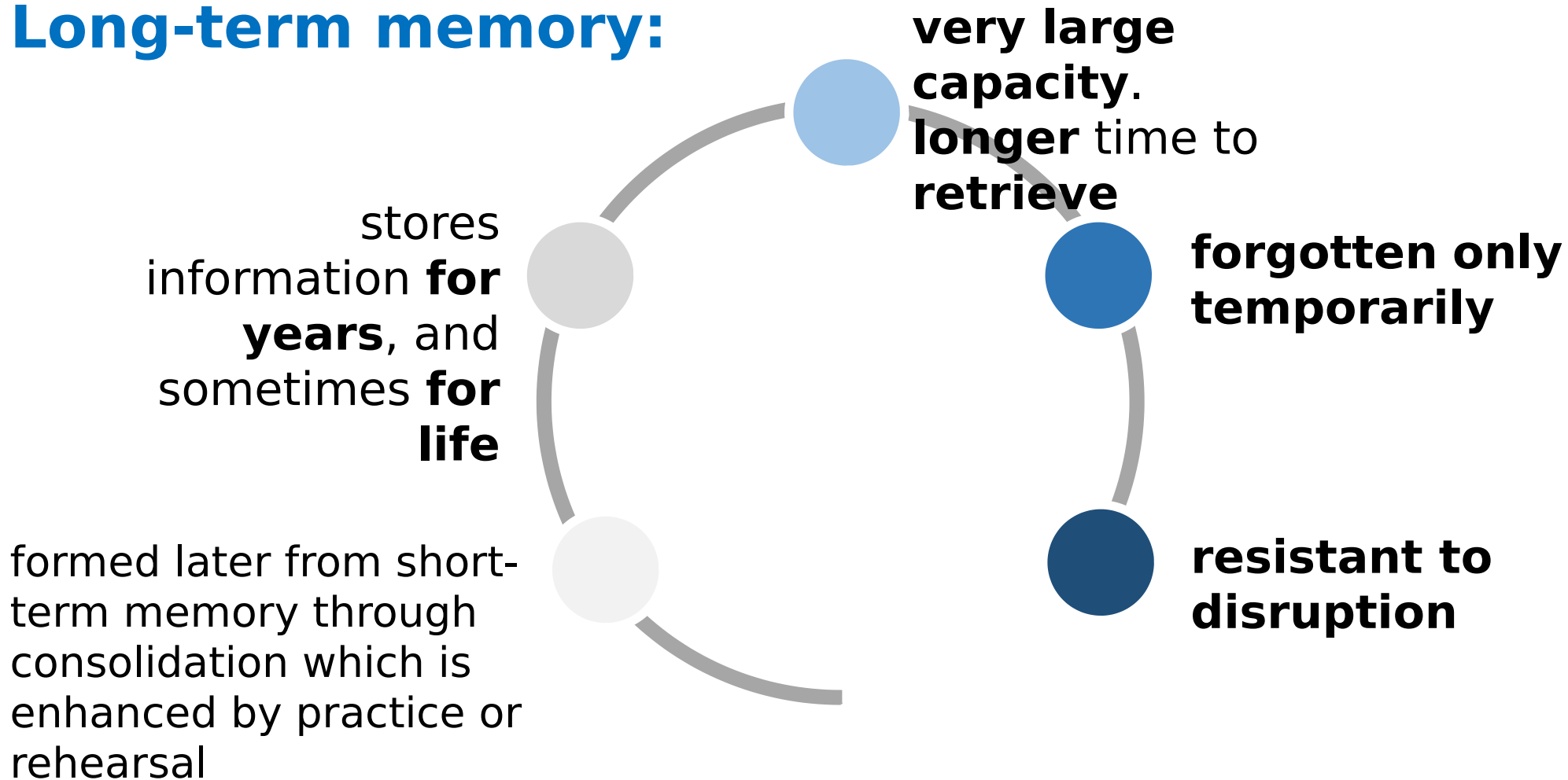
Mechanism of short-term memory:

- Is **transient** modifications in the **function of preexisting synapses**:
 - ✓ A temporary change in the amount of neurotransmitter released in response to stimulation
 - ✓ A temporary change responsiveness of the postsynaptic cell to the neurotransmitter within affected nerve pathways
- The activity of preexisting synapses changes through **post tetanic potentiation**, **short-term habituation** or **short-term sensitization**

Temporal Classification



Long-term memory:



Temporal Classification



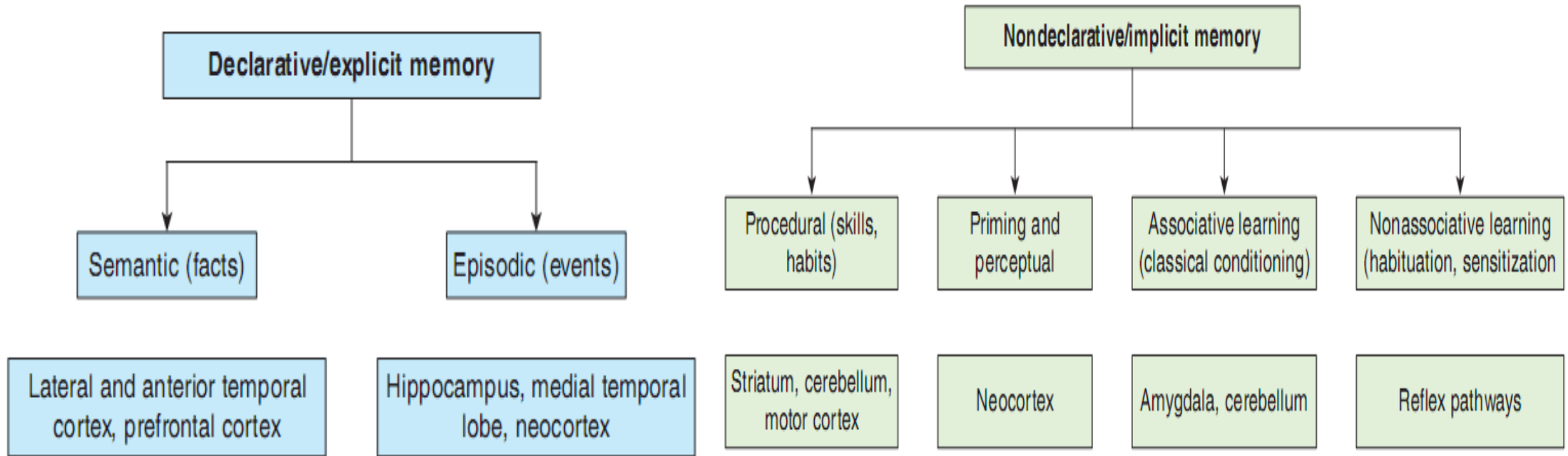
Mechanism of long-term memory:

- **Permanent functional or structural changes** between existing neurons through **activation of specific genes** that control synthesis of proteins, needed for this permanent change
 - ✓ Formation of **new synaptic connections** by increase the number of dendritic spines or the number of synapses on the dendrites of postsynaptic neurons
 - ✓ Increase **enzymes** inducing transmitter synthesis
 - ✓ Increase number of **transmitter vesicles**
 - ✓ Increase number of transmitter **releasing sites**
 - ✓ Addition of **more receptor sites**
- The activity of the permanent synapses changes through **long term potentiation, long-term habituation or long-term sensitization**

Physiological classification:



Based on type of information stored how it is stored



Ganong's Review of Medical Physiology 25th Edition, 2016

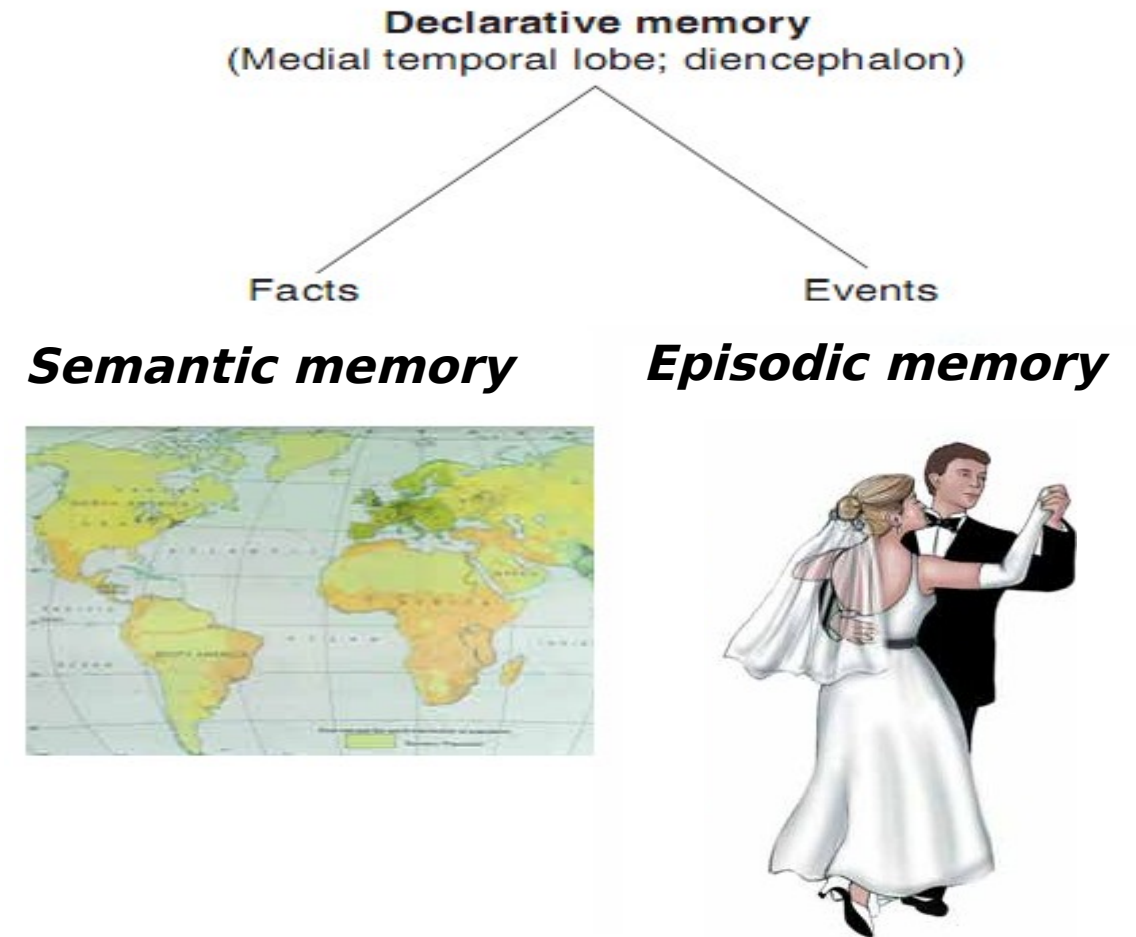
I. Explicit memory (Conscious) = Declarative (recognition) memory



- It is the memory for factual knowledge about people, places, and things.

- It involves **conscious recall** or **awareness** after short time of thinking of some related events.

- Depend on **hippocampus** and retained in **medial temporal** lobe of the brain, **neocortex** and **prefrontal cortex**.



NEUROSCIENCE EXPLORING THE BRAIN, FOURTH EDITION, Wolters Kluwer, 2016

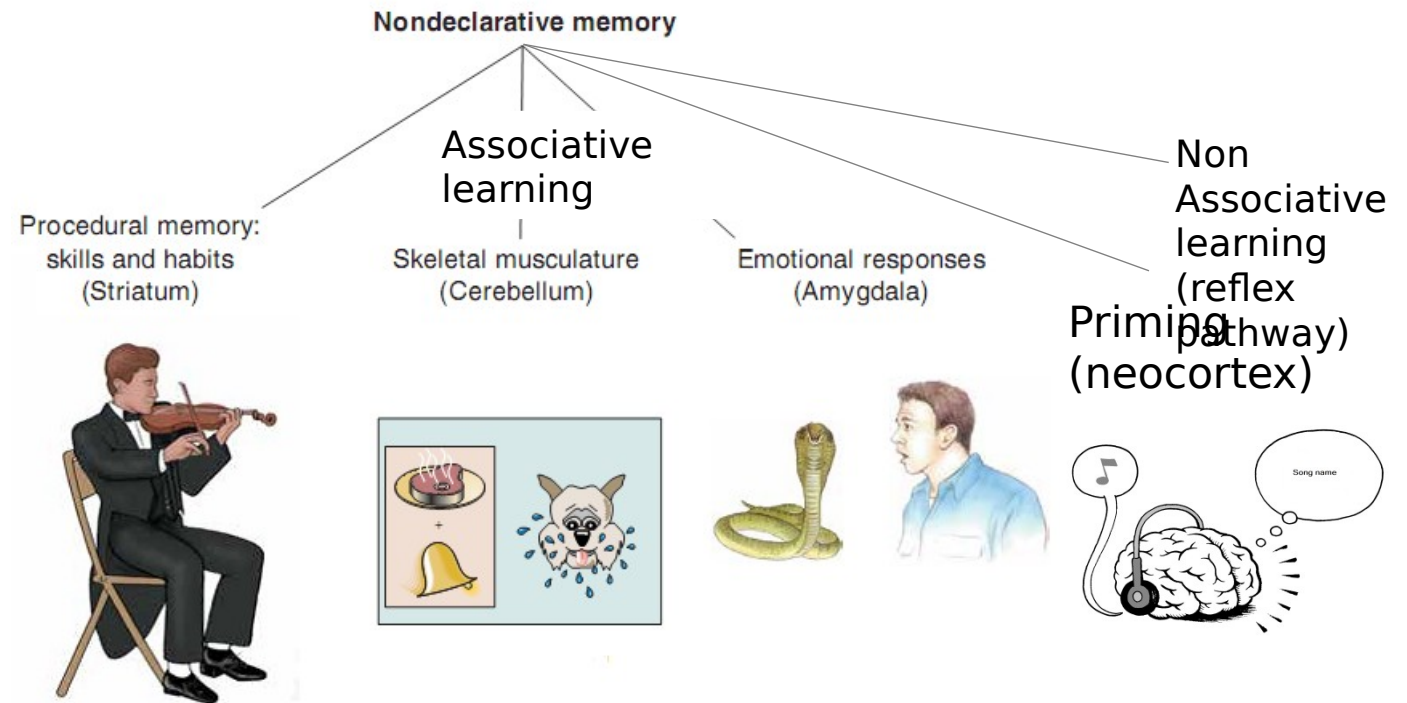
II. Implicit memory (Unconscious) = Procedural memory = Non declarative (Reflexive) memory



- It is the memory for training reflexive motor or perceptual skills, **tasks and habits.**

- It does not involve awareness (**unconscious**)

- Its retention does **not** usually involve processing in the **hippocampus**.



NEUROSCIENCE EXPLORING THE BRAIN, FOURTH EDITION, Wolters Kluwer, 2016

II. Implicit memory (Unconscious) = Procedural memory = Non declarative (Reflexive) memory



Priming: it is the facilitation of the recognition of words or objects by prior exposure to them.

It is dependent on the **neocortex** e.g. recall of a word when presented with the first few letters of it.

Procedural memory: includes skills and habits, which, once acquired, become unconscious and automatic.

It is processed in the **striatum and cerebellum**.

Non-Associative learning: includes habituation and sensitization.

It is dependent on **various reflex pathways**.

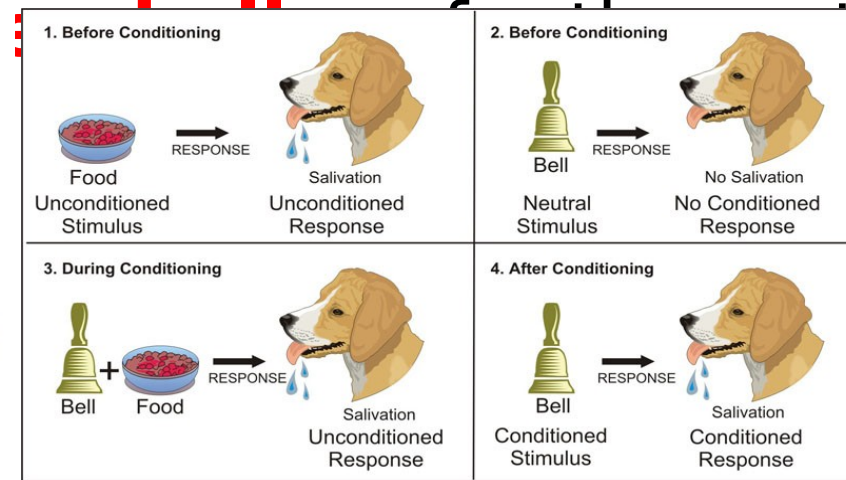
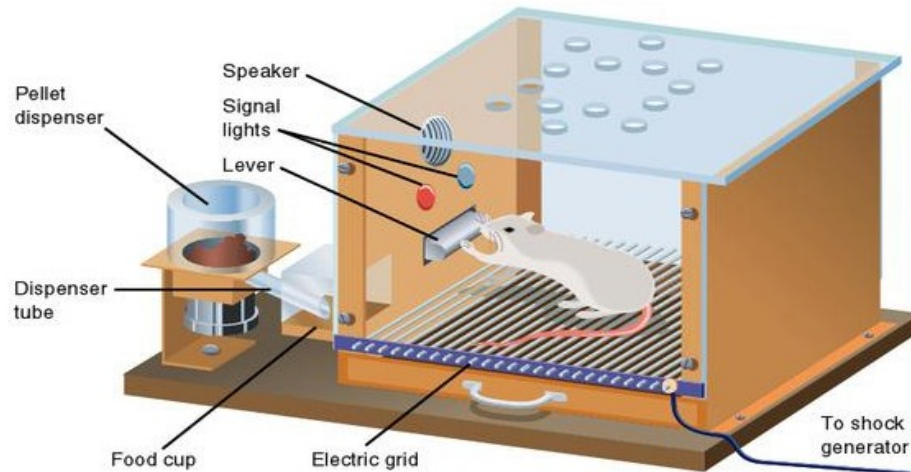
II. Implicit memory (Unconscious) = Procedural memory = Non declarative (Reflexive) memory



Associative learning: classical conditioning (learning a relationship between **two stimuli** e.g. Pavlov's experiments) and operant conditioning (it is the use of consequences (**reward or punishment**) to modify the occurrence and form of behavior).

This type of memory is dependent on the **amygdala** for its emotional response

<https://www.simplypsychology.org/operant-conditioning.html>



Classical Conditioning

or

<http://www.wattsburg.org/Unit5Learning.aspx>

Memory traces are present in multiple regions of the brain



There is **no single “memory center”** in the brain. Instead, the neurons involved in memory traces are widely distributed throughout the subcortical and cortical regions of the brain.

- o Declarative memory → hippocampus and retained in medial temporal lobe of the brain, neocortex and prefrontal cortex.
- o Priming → neocortex
- o Procedural memory → striatum and cerebellum
- o Associative learning → amygdala for its emotional responses and the cerebellum for the motor responses
- o Non-Associative learning → various reflex pathways

The hippocampus → declarative memories and encoding of short-term memories into long-term memories

Role of synaptic plasticity in memory



1- Posttetanic potentiation:

It is **enhanced** response of postsynaptic neuron to a **brief tetanizing** train of stimuli. This enhancement lasts for seconds.

It is the basis of **short-term memory**

Mechanism:

Increase neurotransmitter release due to **accumulation of Ca^{2+}** in the presynaptic neuron caused by the tetanizing stimulation.

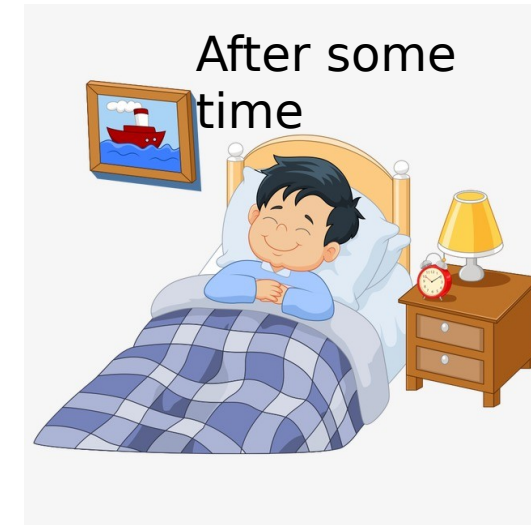


2- Habituation

It is gradual **decrease** in response with repetition of unimportant stimulus.

It is most common form of learning (**non-associative learning**).

The person become habituated and **ignores** the insignificant stimulus, e.g. sleeping in noise ignoring the sound of dogs.



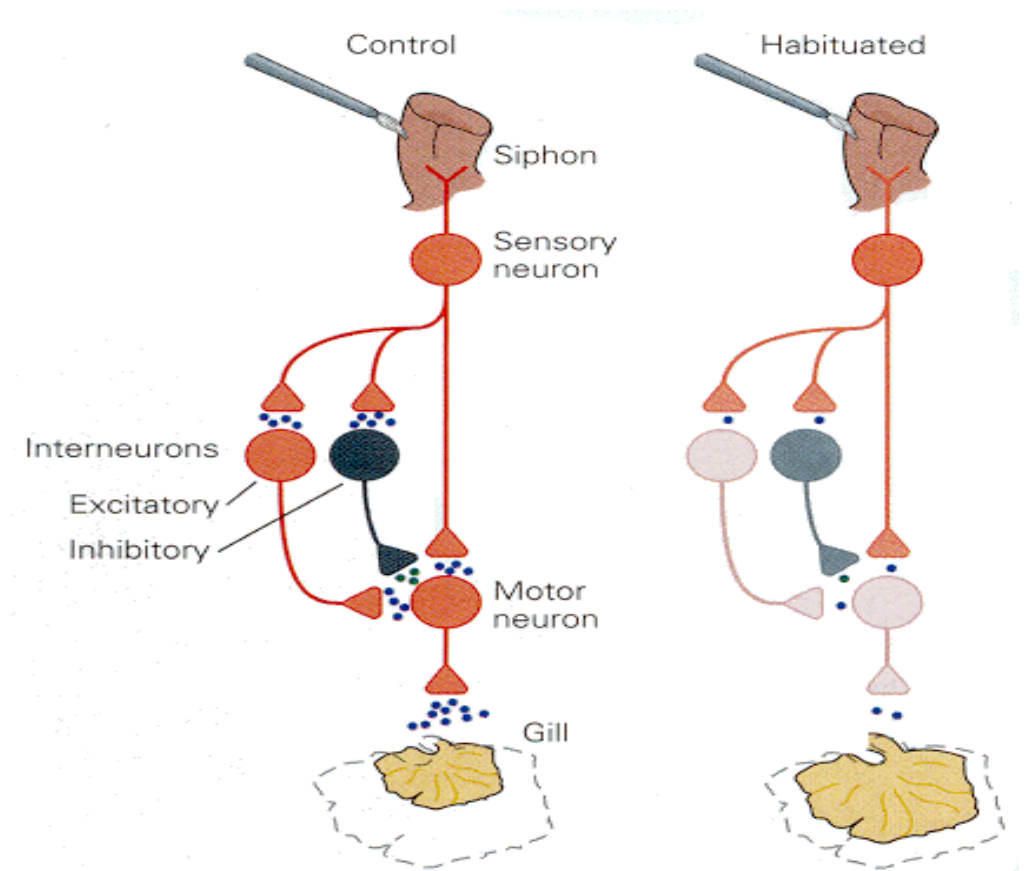
Role of synaptic plasticity in memory



It can be **short term**, or it can be **prolonged** if exposure to the benign stimulus is repeated many times

Mechanism:

Gradual **inactivation** of Ca^{2+} channels at presynaptic neuron by repeated stimulation $\rightarrow \downarrow \text{Ca}^{2+}$ in presynaptic neuron $\rightarrow \downarrow$ **release of neurotransmitter** from presynaptic neurons.



<http://michaeldmann.net/mann18.html>



3- Sensitization

It is progressive **amplification** of a response to a previous habituated stimulus when it is coupled one or more times with **unpleasant stimulus** e.g. person bitten by dog avoids all dogs.

It can be **short-term** or **long-term** depending on the degree of exposure the sensitizing stimulus



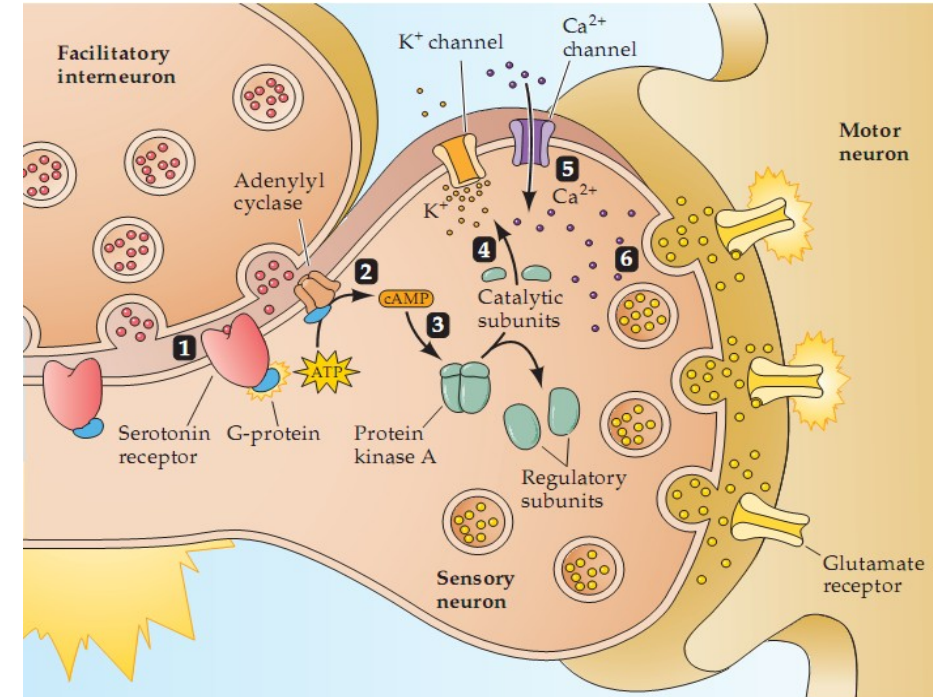
Role of synaptic plasticity in memory



Mechanism: (presynaptic facilitation)

The noxious stimulus causes **serotonin** release from facilitating interneuron that synapses on the **presynaptic neuron** → **increase cAMP**

→ **decrease K^+ efflux** due to channel closure
→ prolongation of action potentials at presynaptic neurons → **increase Ca^{2+} influx**
→ increased transmitter release by the synapse.



NEUROSCIENCE, Fifth Edition
2012



4- Long-term potentiation (LTP):

It is **persistent enhancement** of synaptic efficacy of **both** presynaptic (**greater transmitter release**) and postsynaptic (**greater sensitivity to transmitter**) neurons following a brief period of rapidly repeated stimulation of the presynaptic neuron.

Such changes can **persist for days to weeks**, long enough for the short-term memory to be **consolidated** into more permanent long-term memory.

LTP occurs in many parts of the nervous system but are most prominent in the **hippocampus**, a site critical for converting short-term memories into long-term memories

Role of synaptic plasticity in memory

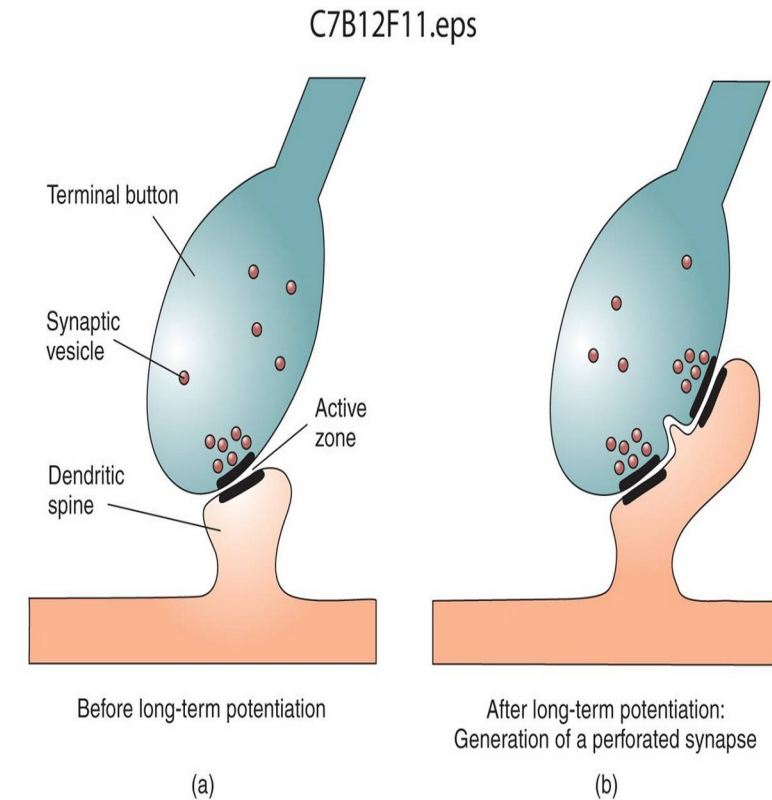


Mechanism:

LTP is initiated by an increase the **entry of Ca^{2+}** in **postsynaptic neuron**. Ca^{2+} entrance occurs through **NMDA** receptor of **glutamate**

Ca^{2+} entrance **activates protein kinases** which phosphorylates proteins causing **movement of more receptors** to the synaptic membrane and **increasing their conduction**.

After appropriate stimulation of a presynaptic pathway, the **number of dendritic spines** and the **number of synapses** on the dendrites of postsynaptic neurons **increase rapidly** increasing the connection between the presynaptic and



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Temporal Classification:

Characteristic	Short-Term Memory	Long-Term Memory
Time of Storage after Acquisition of New Information	from immediate memory by Mental or verbal repetition of information	Later; must be transferred from short-term to long-term memory through consolidation; enhanced by practice or rehearsal
Duration	Lasts for seconds to hours	Retained for days to years
Capacity of Storage	Limited	Very large
Retrieval Time (remembering)	Rapid retrieval	Slower retrieval, except for thoroughly ingrained memories are rapidly retrieved
Inability to Retrieve (forgetting)	Permanently forgotten; unless consolidated into long-term memory	Usually only transiently unable to access
Mechanism of Storage and role of synaptic plasticity	transient modifications in functions of preexisting synapses post tetanic potentiation, short-term habituation or short-term	permanent functional or structural changes between existing neurons long term potentiation, long-term habituation or long-term sensitization

Summery



Physiological Classification:

Explicit memory (Conscious) = Declarative (recognition) memory	Implicit memory (Unconscious) = Procedural memory = Non declarative (Reflexive) memory
Memory factual knowledge about people, places, and things.	Memory for training reflexive motor or perceptual skills, tasks and habits.
Need conscious recall or awareness	Does not involve awareness (unconscious)
Depend on hippocampus	Does not usually involve processing in the hippocampus
Types: Semantic memory Episodic memory (medial temporal lobe of the brain, neocortex and prefrontal cortex.)	Priming (Neocortex) Procedural memory (Striatum and cerebellum) Associative learning: motor responses (cerebellum) emotional responses (Amygdala) Non-Associative learning (reflex pathways)



1- Classical conditioning is an example of which of the following?

- A. Semantic memory
- B. Episodic memory
- C. Implicit memory
- D. Priming memory
- E. Procedural memory



2- Which of the following is most severely impaired in patient with hippocampus lesion?

- A. Episodic memory
- B. Associated memory
- C. Priming memory
- D. Non associated memory
- E. Procedural memory

SUGGESTED TEXTBOOKS



1. Ganong's Review of Medical Physiology, twenty-fifth edition 2016, McGraw-Hill Education, chapter 15, from page 283 to 295.
2. Human Physiology: From Cells to Systems, Ninth edition 2016. by CENGAGE, chapter 5, from page 157 to 163
Lauralee Sherwood
3. NEUROSCIENCE, sixth edition 2018, Oxford University Press, chapter 30, from page 681 to 702.

**Please don't
forget
*Thank You***

